U.S.N.										

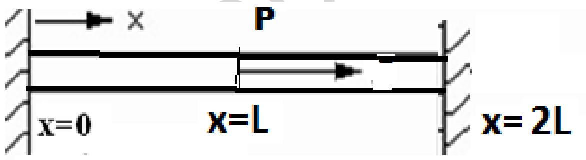
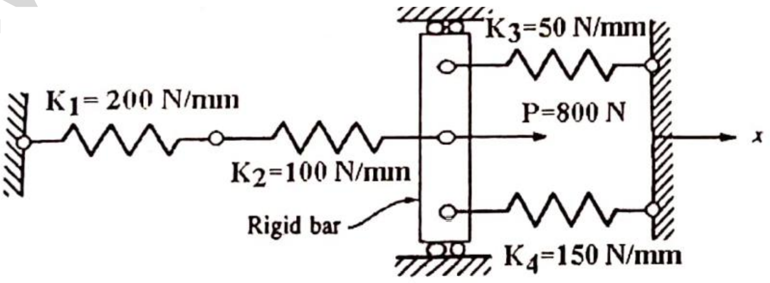
B.M.S. College of Engineering, Bengaluru-560019

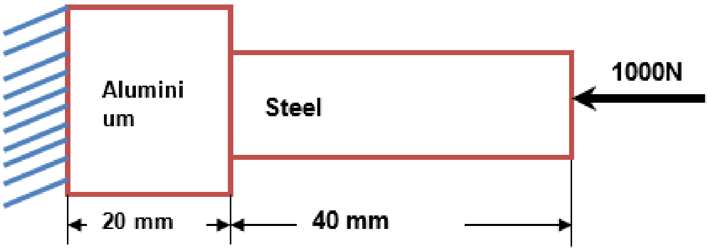
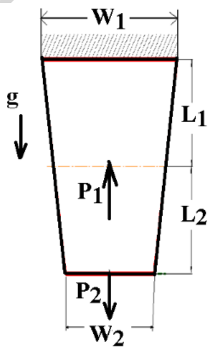
Autonomous Institute Affiliated to VTU

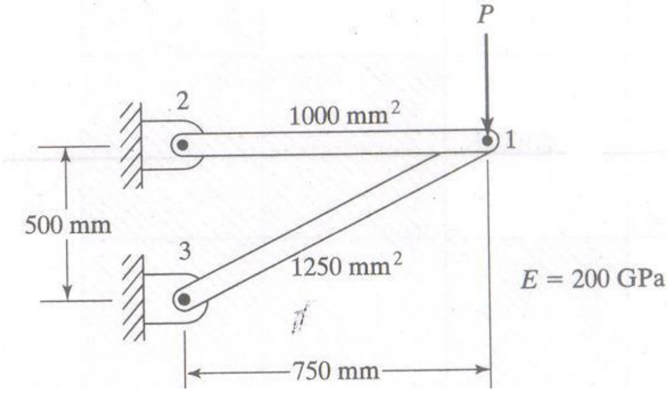
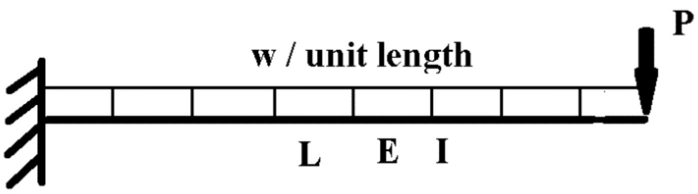
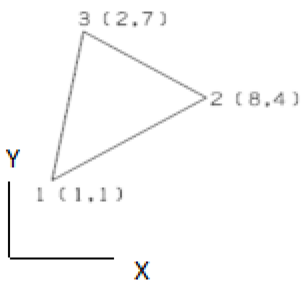
January / February 2025 Semester End Main Examinations

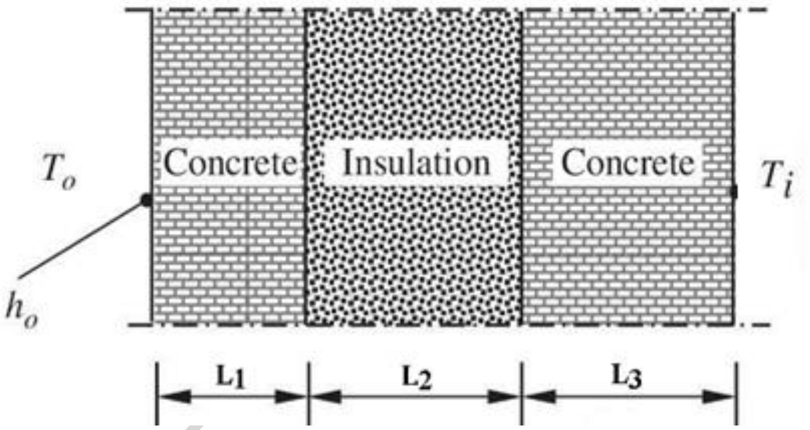
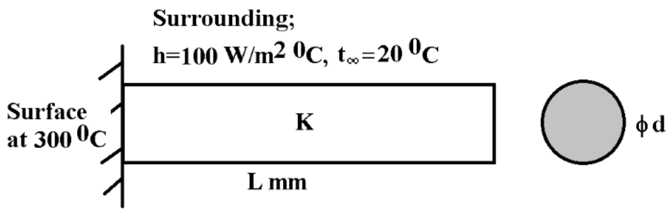
Programme: B.E. **Semester: VI**
Branch: Mechanical Engineering **Duration: 3 hrs.**
Course Code: 22ME5PCMFE / 20ME6DCMFE **Max Marks: 100**
Course: Modelling and Finite Element Analysis

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

		UNIT - I	CO	PO	Marks
1	a)	Write the following in the matrix form 1. Equilibrium equations in 3D 2. Strain-displacement relations in 3D 3. Stress-strain relations in 3D 4. Stress-strain relations for Plane stress condition	CO1	PO1 PO2	**08**
	b)	Using the Rayleigh-Ritz method obtain expressions for displacement and stress for the uniform bar shown in the fig 1. What is the maximum displacement if P = A = L = E = 1?  **Fig. 1**	CO1	PO1 PO2	**12**
		OR			
2	a)	Determine the nodal displacements for the spring system shown in fig 2a using principle of minimum potential energy.  Fig 2a	CO1	PO1 PO2	**10**
	b)	Evaluate the following integral with suitable Gauss quadrature. Verify the answer with analytical solution. $I = \int_0^3 (1 + 2r + 3r^2 + 4r^3)\,dr$	CO1	PO1 PO2	**06**

	c)	With suitable examples, differentiate essential and non-essential boundary conditions.	*CO1*	*PO1* *PO2*	**04**
		UNIT - II			
3	a)	Formulate the element stiffness matrix for a 2-noded bar element with 1-dof at each node.	*CO2*	*PO1* *PO3*	**08**
	b)	Determine displacement field, support reactions and stresses for the stepped bar shown in fig 3b. A_{Al} = 40 mm^2, E_{Al} =70x10^3 N/mm^2, A_{ST} = 20 mm^2, E_{ST} =200x10^3 N/mm^2.  Figure 3b	*CO2*	*PO1* *PO3*	**12**
		OR			
4	a)	Derive shape functions for 2-noded bar element in natural coordinate system.	*CO2*	*PO1* *PO3*	**06**
	b)	For the problem shown in figure 4b, determine the nodal displacements, element stresses and reactions. Thickness of the plate = 5 mm, W_1=50 mm, W_2=30 mm. Density = 8000 kg/m^3 and E=100GPa. Consider L_1=1.5 m, L_2=1.5 m, P_1=70kN, and P_2=70kN.  Figure 4b	*CO4* *CO6*	*PO1* *PO2*	**14**
		UNIT - III			
5	a)	Derive Hermitian shape functions for a 2-noded beam element and sketch their variation.	*CO* *CO3*	*PO1* *PO2*	**08**
	b)	For the pin-jointed configuration shown in figure 5b, determine the element stiffness matrix, displacement vector, and stresses in the elements if P = 10 kN.	*CO* *CO3*	*PO1* *PO2*	**12**

			 Fig 5b			
			OR			
6	a)	Derive the element stiffness matrix for 2-noded plane truss element.	*CO2*	*PO1*	**06**
	b)	For the beam loaded as shown in fig 6b, determine the nodal unknowns and support reactions. E=200 GPa, I=10×10^{-4} m^4. Take L=3m, w=10N/m, P=50kN.  Fig. 6b	*CO2* *CO3*	*PO2*	**14**
			UNIT - IV			
7	a)	Sketch 2D constant strain element indicating the degrees of freedom. Obtain expressions for i) Shape functions, ii) Jacobian, and iii) Strain-displacement matrix	*CO2* *CO3*	*PO2*	**12**
	b)	For the triangular element shown in fig 7b, determine the strains ε_x, ε_y and γ_{xy} given displacements q_1 = 0.001, q_2 = -0.004, q_3 = 0.003, q_4 = 0.002, q_5 = -0.002 and q_6 = 0.005.  Fig.7b	*CO2* *CO3*	*PO2*	**08**
			OR			
8	a)	Formulate shape functions for 3-noded quadratic bar element,	*CO4*	*PO1* *PO2*	**06**

		b)	Sketch 9-noded quadrilateral element in local coordinates. Identify nodal coordinates and write the shape functions for the same.	*CO4*	*PO1*	**08**
		c)	With suitable illustrations, discuss iso, sub and super-parametric elements.	*CO4*	*PO1*	**06**
			UNIT - V			
	9	a)	Derive shape functions for a 2-noded one-dimensional heat transfer element in global coordinates.	*CO4*	*PO1* *PO2*	**06**
		b)	Consider a wall built up of concrete and thermal insulation. The outdoor temperature is T_0= - 15 ℃, and the temperature inside is T_i= 30 ℃. The wall is subdivided into three layers as shown in fig 9b. The thermal conductivity for concrete is K_c= 2 W/m℃ and that of the insulator is K_i=0.05 W/m℃. Convection heat transfer is occurring at outer surface with convection coefficient of h_0 = 24 W/m^2 ℃. Obtain the temperature distribution in the wall. Take L_1=5 cm, L_2=25 cm, L_3=50 cm.  Fig 9b	*CO4*	*PO1* *PO2*	**14**
			OR			
	10	a)	Derive shape functions for 2-noded one-dimensional heat transfer element in natural coordinate system.	*CO4*	*PO1* *PO2*	**06**
		b)	Determine the temperature distribution and amount of heat transfer in a rectangular fin as shown in figure 10b. Use two 2-noded 1-D heat transfer elements. Also obtain the temperature at mid-point of the 1st element. Assume that the end face of the fin is insulated. L=0.05 m, d=0.01 m, K=50 W/m℃  Fig 10b	*CO4*	*PO1* *PO2*	**14**

******